(A)	(B)	(C)	(D)	(E)	(F)	(G)	REMARKS
BITM	5138208	2.31	601487	42105	0.82	7.01	Inclusive
NSCD	13782976	1.71	842530	2528	0.02	0.31	No/Poor Inclusion
VITM	5101000	1.78	1126000	2252	0.05	0.2	No/Poor Inclusion
NSCM	11914398	1.63	912134	1185	0.01	0.13	No/Poor Inclusion
SCTY	5138208	2.31	1400000	496	0.01	0.04	No/Poor Inclusion
RSCL	3226000	2.08	336139	6723	0.21	2.01	Less Inclusive
RSCBBSR	1900000	2.78	398584	1794	0.1	0.46	Less Inclusive
RSCG	818809	1.99	346758	72820	8.9	21.01	Highly Inclusive
RSCNAG	2420000	1.63	363000	5445	0.23	1.5	Inclusive
RSCBHO	1458416	2.34	182320	912	0.07	0.51	Poor Inclusion
RSCCALI	436556	2.71	700000	70000	6.04	10	Highly Inclusive
SSCP	1885470	2.28	262000	3930	0.21	1.5	Less Inclusive
KPSC	215443	2.16	836514	9202	4.28	1.11	Inclusive
NBSC	284602	2.31	248000	1265	0.45	0.52	Less Inclusive
RSCT	250821	1.8	337000	5055	2.02	1.5	Inclusive
SCBUR	331759	2.31	152620	3053	0.93	2.01	Inclusive
DSCDGA	1202047	2.31	217357	0	0	0	NA
DSCDKL	1900000	2.78	157508	804	0.05	0.52	No/Poor Inclusion
DSCGUL	427929	1.78	293321	5867	1.38	2.01	Inclusive
DSCDHAR	19932	2.07	192405	14	0.08	0.01	No/Poor Inclusion
DSCTIRU	431603	2.64	330000	8250	1.92	2.5	Inclusive
DSCPURU	113766	2.31	175000	0	0	0	NA
GSC	1200000	1.17	117521	1176	0.1	1.01	Less Inclusive
SCPB	100186	1.99	40500	608	0.61	1.51	Inclusive
APSC	34970	3.04	21757	349	1	1.61	Inclusive
NAGSC	165782	1.34	15000	1200	0.73	8	Inclusive
SHISC	232946	1.25	17200	862	0.38	5.02	Inclusive
SSC	29354	3.77	4000	0	0	0	NA
MANSC	217275	1.31	34000	340	0.16	1	Inclusive
SUKACK	189327	1.85	60000	0	0	0	NA
PGSC	709255	1.75	375000	750	0.11	0.2	No/Poor Inclusion
TNSTC	4216268	2.64	812164	28426	0.68	3.51	Inclusive
BMPIL	26219	2.5	20000	1200	4.58	6	Highly Inclusive
RMNHBHO	1458416	2.34	45000	0	0	0	NA
RMNHBBSR	1900000	2.78	250180	5004	0.27	2.01	Inclusive
PSPBBSR	1900000	2.78	130000	2600	0.14	2	No/Poor Inclusion
SCSOLA	873037	1.63	36200	2534	0.3	7	Inclusive
MSPSSC	331759	2.31	NA	0	0	0	NA
GUWPLA	818809	1.99	168900	10134	1.24	6	Highly Inclusive
MIZOSC	228280	1.81	143272	946	0.42	0.67	Less Inclusive

Table 2

(A) Name of the Centre.
(B) Local Population (Centre Location) as per 2001 Census.
(C) Avg. % of Disable Population of the area (Assuming it to be homogeneous in the state) as per 2001 Census.
(D) Total visitor to the Centre and its outreach programmes.
(E) Total PC & MC Visitors to the Science Centres.
(F) Avg. % of PC & MC visitors in Science Centres w.r.t Local Population.
(G) Avg. % of PC & MC visitors w.r.t total visitors in Science Centres.

[The yardstick is set considering both the % of PC & MC visitors in Science Centres w.r.t Local Population and % of PC & MC visitors w.r.t total visitors in Science Centres].

Inference from Table 2:

Most of Indian science centres/museums are inclusive in terms of visitation of physically and mentally challenged people.

However, some of the centres like NSCD, VITM, NSCM, SCTY, PGSC, DSCDKL, PSPBBSR and RSCBHO are very poor i.e. non inclusive for the group of visitors with special needs.

Centres like RSCG, RSCCALI, BMPIL and GUWPLA are among the highly inclusive centres in terms of visitation of physically and mentally challenged people.

Conclusion

While in this article it has been endeavoured to highlight the areas of social inclusiveness of Indian science centres and museums in terms of physical accessibility, employability and other related social parameters, the Part III of this study will deal with the parameters like cognitive accessibility, financial accessibility, emotional accessibility aspects of this sector in Indian scenario.

Acknowledgement

The author sincerely acknowledges the cooperation extended by the heads of science museums and centres that came forward to respond to the questionnaire survey and Shri Rajarshi Bhattacharjee of CRTL who assisted in compiling data for statistical analysis.

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Appendix A

Social Inclusion Data for Science Centers and Science Museums
(Survey Questionnaire)
Central Research and Training Laboratory
National Council of Science Museums, India

Institutional Information
Name:
Address:
State: Country:
PIN/ZIP:
Name of the Head of the Institute/CEO:
Position:
Phone:
Email:

1. Please tick which ONE of the following BEST describes your institution:
   a. Science Center [ ]
   b. Science Museum [ ]
   c. Planetarium [ ]
   d. Natural History Museum [ ]
   e. Others [ ] Please specify:
2. In which year your institution was first opened regularly to the public? [ ]
3. Does your institution charge a general admission fee?
   1. Yes [ ]
   2. No [ ]
4. How much floor space in your institution is for public use?

   (Exclude areas such as offices, workshops, storage space etc.)

   Indoor : _____ square metres
   Outdoor : _____ square metres

Note: *(1000 sq feet = 93 sq metres, if your institution has more than one building / site, please show* combined *floor area)*

Number of days in a year that your institute remains open:

(Remarks: To discern the center in a better way)

Area of Your Centre

5. How do you characterize the area of your centre: Is it situated in a cosmopolitan city area or in a tourist spot or in a suburban or rural area?
6. What is your observation on the financial and social condition of the local population of the surrounding area? (e.g. whether agrarian economy, surrounded by any ethnic community)

Financial (Please tick)		Social Resolution
1) Agrarian Economy	[ ]	1) Major Linguist group:
2) Business driven economy	[ ]	2) Ethnic Group(s) (if any):
3) Mixed Economy	[ ]	3) Mixed population group:
4) Others (specify)	[ ]	4) Others (specify) :

(Remarks: To know the socio-economic resolution of the area, help understand the social exclusiveness)

Your staff (based on the recent statistics)

7. How many staff, including 'active friends' and volunteers, worked for your institution?

	Category of staff	Number
5.1	Total paid full-time staff	
5.1.1	Total Female paid full-time staff	
5.1.2	Total physically challenged paid full-time staff	
5.1.3	Total scheduled caste (SC) / scheduled tribe (ST) / backward class (OBC) paid full-time staff	
5.1.4	Total minority paid full-time staff	
5.2	Total paid part time staff	
5.2.1	Total Female paid part time staff	
5.2.2	Total physically challenged paid part time staff	
5.2.3	Total scheduled caste (SC) / scheduled tribe (ST) / backward class (OBC) paid part time staff	
5.2.4	Total minority paid part time staff	
5.3	Total Full Time Equivalent (FTE) paid staff (Trainees/Contract etc.)	
5.3.1	Total Female FTE paid staff	
5.3.2	Total physically challenged FTE paid staff	
5.3.3	Total scheduled caste (SC) / scheduled tribe (ST) / backward class (OBC) FTE paid staff	
5.3.4	Total minority FTE paid staff	
5.4	Unpaid staff-voluteers and 'active friends'	
5.4.1	Female Unpaid staff-voluteers and 'active friends'	
5.4.2	Physically challenged Unpaid staff-volunteers and 'active friends'	
5.4.3	Scheduled caste (SC) / scheduled tribe (ST) / backward class (OBC)	
5.4.4	Minority Unpaid staff-volunteers and 'active friends'	

8. Values and attitudes of your staff towards the centre/museum:

Value Attitude (Please tick)	
1) Passionate	[ ]
2) Dutiful	[ ]
3) Regular	[ ]
4) Indifferent	[ ]
5) Others (specify)	[ ]

9. Distribution of functionality of your staff in terms of number of Educators, Scientific/Technical Staff:

(Remarks: to assess the social distribution of the staff members (though in a Govt. org recruitment is highly regulated by govt. norms) and their functionality)

Your Fee structure

10. What is your entry-gate fee?

11. What are the other facilities with additional fees?

Name: Fee: (mention currency)

(Remarks: it is worth noting to Social Inclusion that some have a marketing agenda)

Profile of Your Visitors

12. Your visitors (you can give an approximate average numerical data)

a) On-site attendance?
b) Off-site attendance?
(Consider mainly the outreach programmes conducted by you, if necessary classify these like Mobile Science Exhibitions, Participation in Fairs etc.)
c) What is the approximate percentage of the visitors coming from the outside? (At least 50 km away from the centre)
d) What percentage of your visitors comes in a group? (families or friends in groups of 3 or more)
e) What percentage of your visitors is 'students' or 'students in groups'? (approximately)
f) What percentage of your visitors is physically challenged?
g) What percentage of your visitors is mentally challenged?

(Remarks: to assess the Social Inclusiveness and acceptability of the Centre to the different class of the society)

Your Social Activity Orientation

13. What is your idea of 'social exclusion' (50 words approx)?

14. What is your idea of 'social inclusion' (50 words approx)?

15. How many programmes did you conduct (during the last five years) where schools participated? (Programmes like Science Fair, Creative Ability Centre etc.) If possible, please give a separate brief account (50 words) of each of these programmes.

16. How many times did your representatives visit the schools in the last three years?

17. Did you ever conduct any programme targeting groups with special needs in last five years (say, visually challenged and/or visitors with hearing or speech impairment, orthopedically handicapped groups etc.)

Name: Year: Duration (days): Participants: Remarks:

18. Please give a brief account of those programmes you conducted targeting senior citizens and women in last five years? (Please specify the programmes)

Name: Year: Duration (days): Participants: Remarks:

19. Have you ever conducted any programme for Personal Growth and Development in last five years? Please give a brief description. (The Programmes are supposed to make significant differences in the lives of individuals at risk of financial, intellectual and social disadvantages. Expected outcomes include enhanced self-esteem, confidence and creativity, which, in turn, have helped people develop more active, fulfilled and social lives)

Name: Year: Duration (days): Participants: Remarks:

20. Have you ever conducted any programme for community empowerment in last five years? Give a brief account.

Name: Year: Duration (days): Participants: Remarks:

21. Have you ever conducted any programme directed towards tackling the problem of unemployment? Please elaborate.

Name: Year: Duration (days): Participants: Remarks:

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22. Have you ever conducted any programme for tackling the problem of crime, directly or indirectly? Please elaborate.

Name: Year: Duration (days): Participants: Remarks:

(Remarks: to assess the Social Inclusiveness of the Centre by the means of its activity towards social inclusion and how included is society interpersonally to your centre)

Steps Taken/Envisaged for the Publicity of Your Centre vis-à-vis social inclusion

23. State briefly the steps taken for the publicity of your centre. (not only to bring more visitors but to project the centre as an institution for Social Inclusion i.e. including more people from all strata of the society)

24. What is your budget allocation in publicity?
Total Budget in Publicity:
Budget for publicity towards programs aiming social inclusion:

(Remarks: Visitor development initiative is also a step towards Social Inclusiveness for a Centre)

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Portrayal and Preservation of Indigenous Methods of Visual Communication through Indian Museums

Supreo Chanda

The tradition of using visual appeal for conveying profound cultural message is a typically Indian achievement as evidenced in the potteries, sculptures, temple reliefs, literature, paintings, dances, dramas, etc. through the ages and can be found in every corner of the country. The relief sculptures on the relics of early *stupas*, murals on the walls of ancient rock-cut edifices or the rich medieval temple architectures give captivating glimpses of the Indian life in the past.

The pre-Indus potteries in the hill-slope villages of Baluchistan (Fig. 1.) are typified by series of horizontal

Fig. 1. Prehistoric potteries of Indus Valley and Baluchistan.

horizontal panel or frame to accommodate illustrations of plant and animals. These horizontal bands on the round potteries present the visual image in a system of continuous or recurrent presence. It may be relevant to recall here that in modern exhibition techniques, the horizontal arrangement at the eye-level is a basic method of widest application.

Potteries found from the flood plains of the Indus (Fig. 2.) show a system of making a design based on

Fig. 2. Pottery fragments from Mohenjo-daro.

interesting circles, which is most sophisticated and geometrically accomplished. Apart from these, potteries with peepul leaves occasionally with small birds sitting on the branches are also found. The Cemetery 'H' fuminary potteries show horizontal orientations of illustration of a series of peacocks. Again from the pottery illustrations recovered from Lothal of slightly later period, the emergence of beautiful line drawings of deer oriented and adjusted within the horizontal frame can be seen.

The typical Indus valley seals (Fig. 3.) are square in character and always show, in astonishing details, immaculate adjustments of animal figures and human visages in both geometric and realistic representation. Here abstract summarisations of pictographic writing are cleverly adjusted with animal, human and plant life. In a modern exhibition, this type of adjustment is desired in the display composed of pictorial illustrations and highly sophisticated verbal symbols in the form of labels. It must be noted here that in none of the seals of Indus valley, the pictograms eclipsed the importance of the visual appeal of pictorial subjects - a thing, which is always tried to follow in modern displays where the designer would not like to overshadow pictorial objects by superimposing verbal symbols.

Fig. 3. Pre-historic Indus Seals.

During the early historic period, some aspects of Bharhut *stupa* railing and *torana* illustrations are truly astounding and surprisingly modern in basic approach. Bharhut panels show different aspects of Buddha's life and stories from *Jatakas*. These stories and other episodes of Buddhist religion are adjusted either within square or circular frames on pillar uprights (*thavas*) and horizontal bars (*suchis*). Many of these illustrations in relief are supplied with inscriptions in Brahmi characters conveying to the visiting public the names of the stories so depicted. It is notable that in Indian custom pilgrims going to pay their homage to a *stupa* used to go around the whole edifice. This is known as circumambulation or *pradakshina* in technical terms, for which *pradakshinapathas* or pathways of going round a structure were provided. It can be visualised that thousands of common Indians, lettered and

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unlettered, visiting the great *stupa* - eagerly looking at and enjoying illustrations, which were from time to time explained to them by their enlightened brethren.

It is eminently notable that these labelled illustrations of Bharhut are always displayed within the span of eye-level viewing, i.e., an area roughly between two and seven feet from the ground level in height. This area, even after the passage of twenty-two centuries, remains the most valuable display area throughout the world. It is again notable that the Bharhut inscriptional labels are never obtrusive, but placed in such a way that they are practically difficult to be overlooked by the visitors. This is the same purpose for which labelling in exhibitions are utilised.

The relief work on the vertical and horizontal elements of the gate of the Sanchi-*stupa* (Fig. 4.) is the ideal example of *charana-chitras* of the Buddhist period. These vertically and horizontally oriented panels depicting stories are surprisingly similar to the *patachitras* (scroll-painting on clothes or paper) of West Bengal, which are still very much in existence. "The gateways are perhaps more noteworthy for their carved ornamentation than their architecture" (Basham 1981: 351ff).

Fig. 4. Gateway of Sanchi Stupa.

The remains of the royal portrait gallery showing royalty and other notables of the Kushan period are to be looked into. Antiquities from Mathura are extremely important in this regard. The archaeological information again copiously supported by the detailed description of *Pratima Natakam* by the famous classical Indian poet and dramatist Bhâsa. From this dramatic account, it is known that ancestral portrait galleries were kept in ancient India and these galleries were provided with a proper arrangement of staff like the keeper and the cleaner.

It may be pertinent to note here that similar creation of dramatic moments by using the then existing visual methods can also be found in other classical Indian literatures like Banbhatta's *Harshacharita*, Vishakhdatta's *Mudrarakshasha* and Bhababhuti's *Uttarramacharita*, etc. These prove the importance of visual communication in ancient Indian society. In Kautilya's *Arthasastra* separate provisions had been made for the professional communicators like the *shoubhanikas* and the *vagjibanas*.

> Many of the amusements of ancient India were provided by professional entertainers. As well as who practised highly developed arts such as drama, music and dancing, there were others who travelled through town and village, diverting the ordinary folk who could not fully appreciate the nuances of the more sophisticated art forms (Basham 1981: 211 – 212).

In the Hindu temples, in its wide distribution in the Gangetic plains, Orissa, Central India, Northern and North-western India, most judicious use of temples for visual communication can be witnessed. The North Indian or *nagara* temples are generally typified by sculptural illustrations in the lower and middle heights more or less covering the *pabhaga* and *jangha* areas. In this area, within horizontal mouldings, are placed illustrations from various aspects of life at large, which are repeatedly seen and enjoyed, by the masses of pilgrims who used to visit the temple.

What is true for the North is also valid in the case of the *Dravida* structures. Starting from the monolithic *Ratha* temples of Mahabalipuram (Fig. 5.), one comes across royal portraiture, hunting scenes, pastoral life and marches of war depicted beautifully in horizontal orientation. Examples of this type of visual adjustment are too numerous to be noted. Some of the best examples come from the edifices of Belur and Halebid in Karnataka and Amaravati and Nagarjunakonda in Andhra Pradesh, among others.

Fig. 5. Arjuna's Penance at Mahabalipuram.

The temples of Ahichhatra, Bhitargaon and structures at Kausambi, Paharpur, Mynamati, etc., belonging from 4th century AD to the end of the early medieval period, show the same use as expressed above in the form of architectural terracotta panels. There are temples, *stupas*, and other architectural structures also in this group.

The stuccowork of North-western India and Nalanda also made beautiful use of the above method; so also the wooden panels in the South Indian and Deccan temple carts.

The late medieval terracotta temples of Bengal deserve special mention in this regard. The terracotta panels in these temples, especially in Bankura-Bishnupur (Fig. 6.), beautifully depict mythological scenes from the *Ramayana* and the *Puranas* relating to the Vaishnavite tradition, royal court sceneries, hunting scenes, life of common people, etc (Fig. 7.).

Fig. 6. Jor-Bangla Temple at Bishnupur.

Fig. 7. Scenes on the walls of Jor-Bangla Temple.

From the domain of archaeology, architecture and literature, if attention is turned to the visual art, the urge of people to communicate visually even in the pre-historic times can be found. The pre-historic rock-shelter paintings of Bhimbetka (Fig. 8.) and related other sites beautifully depict the abundance of wild life, dancing scenes, etc. in simply drawn lines in almost continuous succession in terms of time, which give a fair idea about the life and rituals of the pre-historic men.

Fig. 8. Pre-historic Rock Painting at Bhimbetka Caves.

Efforts for communication through visual representation for educational purposes have been successfully made through the cave wall paintings of Ajanta. There *Jataka* stories have been conveyed through the murals. Paintings on the walls of the Bagh caves show resemblances to the later Ajanta paintings. This tradition of wall painting continued to the Hindu temples at Badami, Jaina site at Sittannavasal, Tirumalaipuram cave temple, Kailasa temple at Ellora, the early mediaeval temples under the Cholas in Tamil Nadu, temples in Mysore (Karnataka) and Kerala.

The tradition of visual communication has been successfully continued in the form of miniature paintings on palm-leaf or paper. Illustrated Buddhist palm-leaf manuscripts, Jaina palm-leaf or handmade paper manuscripts on the lives of Mahavira and other Jaina saints are examples of such endeavour. Wooden covers of the manuscripts also used to bear illustrations sometimes. The method of palm-leaf illustration was perfected later in Orissa. Even now the art of painting on palm-leaf is thriving in Orissa. There has been a rich tradition of miniature paintings in India as witnessed in different schools of such paintings like the paintings under the Sultanate, Mughal paintings, Rajasthani paintings and Pahari paintings. The famous miniatures of the *Ragamala* series are the unique renditions of the *ragas* of the Hindusthani classical music.

The *kohbar* (nuptial chamber) paintings done by the women of the Madhuban area of Bihar are examples of use of visual communication. Ritual floor designs done by the women of different parts of India like *alpana* of Bengal, *mandana* of Rajasthan, *muggu* of Andhra Pradesh, *kolam* of Kerala, etc. are highly symbolic and communicative. Similar instances can be seen in traditional textile designs and motifs also, e.g., Chamba *rumal*, *kantha* of Bengal, etc. The temple hangings that are painted on clothes, such as *kalamkari* of Andhra Pradesh and *pichhwai* of Nathdwara of Rajasthan may be mentioned here.

Most of the Indian traditional dances use intricate facial, postural and hand symbols to express different emotions. Use of visual symbols is very much in practice in traditional iconography. Even the Hindu priests use a lot of symbolic hand-gestures during performing *pujas*.

There are hundreds of highly communicative traditional performing arts still extant in India. These include scroll paintings like *patachitra* of Bengal (Fig.9.), *pad* of Rajasthan; theatrical arts like *Kuchipudi* of Andhra Pradesh, *Ankiya-nat* of Assam, Seraikela *Chhau* of Bihar (Jharkhand), *Bhavai* of Gujarat, *Kariyala* of Himachal Pradesh, *Bhand Pathar* of Jammu & Kashmir, *Yakshagana* of Karnataka, *Koodiyattam*, *Mudiyettu*, *Chavittu Natakam*, *Kathakali* of Kerala, *Maanch* of Madhya Pradesh, *Tamasha* of Maharashtra, *Jatra* of Orissa & West Bengal, Mayurbhanj *Chhau* of Orissa, *Naqal* of Punjab & Haryana, *Khyal* of

Fig. 9. *Pata-Chitra* of West Bengal.

Rajasthan, *Therukoothu, Kavadi* of Tamil Nadu, *Nautanki, Ram Leela, Ras Leela* of Uttar Pradesh, Purulia *Chhau* of West Bengal, etc.; Ballad forms like *Alah-Udal* of Bundelkhand of Madhya Pradesh, *Pandavani* of Madhya Pradesh (Chhattisgarh), *Povada, Lavani* of Maharashtra, etc.; Story telling forms like *Kathakatā* of West Bengal (Fig.10.),

Fig. 10. Kathakatā of West Bengal.

Dasakathia of Orissa, *Burrakatha* of Andhra Pradesh, etc.; Marionettes of West Bengal (Fig. 11.), Andhra

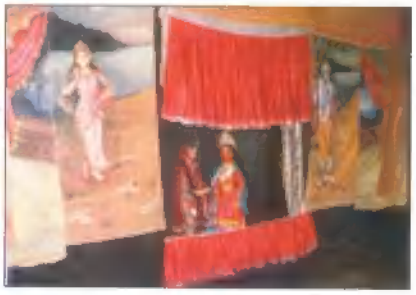

Fig. 11. Marionette of West Bengal.

Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra and Rajasthan; Rod Puppets of West Bengal (Fig. 12.) and Orissa; Glove puppets of West Bengal (Fig. 13.); Shadow plays of Andhra Pradesh, Tamil Nadu, Kerala and Karnataka; Portable shrine of Rajasthan and Andhra Pradesh; etc., and many more.

Fig. 12. Rod Puppet of West Bengal.

Fig. 13. Glove Puppetry of West Bengal.

Though the traditional forms have been displayed as exhibits or objects of curiosity, no serious attempt has been made to utilise their vast communication potentialities. Most of the Indian traditional methods have the flexibility to modify as per the need of the target-audience. Presently almost all forms of traditional performing arts are being used for the rural folks only. Urban people probably would not like the unchanged crude forms unless those are refined to some extent. It is also not much needed to use traditional methods for the educated urban masses because there are many other modes; moreover the education system of present-day India is also Westernised, hence for the educated people the Western educational methods would not be difficult to understand. The rural folk and the low-income group of urban community do like the traditional forms of education and entertainment very much. The traditional forms are primarily meant for the adults, but the children also enjoy - they may not understand the intricate subject matters - the colourful costumes, background and movements with musical accompaniments simply fascinate them and definitely provoke their imagination.

> A devotion to the dead past and the dying culture in the name of 'continuity' and 'speciality' is not the desideratum... It is imperative that Indian art should wean away from ideational stage formed in the name of ancient spirituality as well as medieval mysticism which is the by-product of foreign subjugation, and look into the socio-economic changes that through the forces of Historical Materialism are rapidly taking place (Datta 1956: 100-101).

Traditional methods can be employed in the day-to-day museum educational programmes with a little imagination. As for example, the portable shrine of Rajasthan (*kavad*), which opens frontally part by part thereby gradually unfolding and opening out the picture legend drawn inside, and the painted wooden wedding chest of Orissa can be judiciously used in making the School Loan Kits. Likewise story-telling forms can be incorporated in the story sessions in the children's programmes. Other forms may also be used in one way or other. At least these can be used to attract visitors to the exhibitions and programmes.

The age-old display techniques, like the judicious use of back lighting employed in the shadow puppet performances or in the *Pad* demonstration in the desert under dark night sky; or use of diffused natural light in the old temples and shrines; or the gradual unfolding of *Patachitras* with the progress of narration; etc. should be investigated and made use of. The display techniques employed in the village markets and fairs

may also be noticed taking cognisance of the elaborate arrangements of the merchandise, positions of the trader and customers, etc.

In India, agriculture and religion played most important role in shaping up the traditional art forms.

> Community's own channels for communication are likely to be more effective for disseminating messages. These channels are popularly known as traditional or folk media. The terms 'folk', 'traditional' and 'indigenous' generally refer to the aspects of culture found in peasants and rural people (Das 1992: 44).

Kings, feudal lords and the religious heads readily understood its potentiality and patronised the artist(e)s and successfully utilised their services to disseminate desired messages to the people at large.

> Traditional folk media should not be confused with the technology-based mass media. The technology-based mass media disseminate messages to heterogeneous audiences, whereas the traditional folk media cater to the ethno-rural communities through the functional role of folklore. The folklore phenomenon represents an act of communication employing vocal, verbal-musical and visual art forms, transmitted to a society or a group of societies from one generation to another. They are indigenous modes and have served the society as tools of communication for ages. They have been integrated in the complex body of the socio-cultural behaviour, determined by anthropomorphic existence of the people to which they belong (Parmar 1994: 21-22).

With the change of the feudal system the traditional forms lost their patrons. Moreover in this era of commoditisation of ethnicity, the traditional media are fast losing their character and efficiency to suit the tastes of few rich ethno-maniacs who are also self-proclaimed guardians of ethnic art. In this grim situation the agencies, which were supposed to look after the originality of the traditional arts, have been either unable to cope up with the necessary demands or succumbed to the pressure of the neo-riches to dance in tune with them. Therefore the only option left to preserve the rich heritage of Indian traditional art perhaps is to use them in the more organised and able sector of Indian museums. By doing such, the dual purpose of making museums more effective and preserving an integral part of the cultural heritage would be served, more so because, "It shall be duty of every citizen of India to value and preserve the rich heritage of our composite culture" (Constitution of India, under Fundamental Duties).

In another important development the *Convention for the Safeguarding of the Intangible Heritage*, adopted by the UNESCO General Conference in Paris on 17th October 2003, which came into force on 20th April 2006. India is one of the major signatory countries. The exceptionally rapid ratification of this new instrument that came into force in just two and half years amply shows the great interest in protection of intangible heritage all over the world irrespective of the countries of the South or of the North. It was really necessary legally to have an instrument to combat the threat posed by the Globalisation to safeguard this essential aspect of cultural diversity, which is inherited through tradition. The countries ratifying the Convention commit themselves to take necessary measures to safeguard the intangible heritage on their territory and also to make detailed inventories of the forms extant there. The Convention aims to prepare two lists:

1. Representative List of the Intangible Cultural Heritage of Humanity, and
2. List of Intangible Cultural Heritage in Need of Urgent Safeguarding.

The International Council of Museums (ICOM) fully ratified the Convention. India being one of the *hotspots* of the cultural diversity and the museums portraying majority of the heritage, the Indian museums have great responsibilities in fulfilling the objective of the Convention, especially in the areas of raising public awareness.

> Conservation policies were supposed to be based on critical process starting with 'intrinsic cultural resources and values' related to it. What were these intrinsic values? All along they were considered to be four i.e.: 'material', 'workmanship', 'design', and 'setting'. The primary aim of conservation was to 'safeguard the quality and values of the resource, protect material substance and ensure integrity for posterity' (Fielden and Jokiletho 1993: 11). But could that be all? (Munjeri 2004: 12-13).

To make museums more effective, educationally as well as culturally, such institutions in India perhaps can adopt the traditional visual techniques used in many of its cultural heritage forms, efficacy of which are time-tested, and could run the educational/ extension services in such a manner that people naturally feel attracted to visit museums as national institutions for acquiring knowledge and enjoyment. Intangible elements can also effectively fill the gaps between the evidences of material culture, i.e., the objects.

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> No one could boldly assert that the soul (the intangible) can exist without the body (the tangible) and thus it can be argued philosophically and perhaps logically that the intangible and the tangible are two sides of the same coin… the accepted conclusions of the UNESCO World Commission on Culture and Development which unequivocally states that in any partnership of the tangible and the intangible, 'The tangible can only be interpreted through the intangible' and not vice versa (Munjeri 2000).

Intangible elements are indispensable in supplementing the tangible elements preserved in the museums. Thereby the Indian museums can develop a separate national character and identity.

> Traditional art forms have survived for centuries and they will survive in the future due to their flexibility. They could be the media for social change in rural India. Folk arts being functional, interpersonal and having a contextual base would be able to carry the message of change, development and environmental awareness… (Mukhopadhyay 1994: 3-4).

Museology, may be defined as, the philosophy of visual interpretation of heritage, be it cultural, natural or scientific (Chanda 2008: 21-25). Again, visual culture has emerged across a range of disciplines, including art history, film studies, comparative literature, anthropology and museology, as well as regional and cultural studies. The visible artefact arises out of a set of social and cultural exigencies that create the conditions for seeing that fit into a meaningful structure of information and knowledge.

> The concept of 'visual culture' allows the examination of all those signifying practices, representations and mediations that pertain to looking and seeing, and allows an analysis that is not shaped in advance by the values of high culture. 'Visual culture' as a concept and a methodology refuses to accept the distinction between high and mass culture (Hooper-Greenhill 2000: 14).

Tony Bennett (1995: 163), quoting *Grundrisse*, by Karl Marx, explains the dialectics between production of art and production of aesthetics. Eilean Hooper-Greenhill (2000: 1), again, relates the interpretation of visual culture to museum pedagogy:

> In asking questions about the interpretation of visual culture in museums the themes of narrative, difference, and identity arise in relation to interpretive processes and museum pedagogy. These are complex and multi-layered matters, where meanings routed in the past clash with contemporary interpretations that challenge their continued validity.

By definition, museum is a non-profit, permanent institution **in the service of society** and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the **tangible and intangible heritage of humanity and its environment** for the purposes of education, study and enjoyment (Article 3, Section 1 of the *ICOM Statutes*, adopted by the 22nd General Assembly at Vienna, Austria on 24th August 2007).

> One of the prime functions of the public museum is to present material culture to be viewed… In the museums, objects, or artefacts are put on display. They are there to be looked at (Hooper-Greenhill 2000: 14).

Susane M Pearce (1992: 139-141) describes the process that transforms 'material' into 'museum collection' based on Saussurian semiotic insights.

The concept of intangible heritage, cultural expression, etc., may not be alien to the Indian museums; but to include them in the core functioning of the museums would be a very challenging proposition. Each and every convention, declaration, etc., concerning culture, tangible or intangible, does emphasize on documentation, education and raising awareness among the public for preservation and revitalisation, wherever needed, which constitute the vital activities of museums. In the very near future, preservation of digital heritage will definitely be making its foray into the domain of museums and Museology. Museums have to play greater roles in portraying and preservation of culture and heritage in holistic manners to build up cultural identities in global perspective. Indian museums must come forward to accept the challenge to integrate culture for sustainable development. Cultural plurality of the Indian society makes the task more daunting; at the same time it must be utilised for fruitful interaction between the varied cultures for making the bridges among people for fostering mutual understanding and respect. Museums are the ideal launching pads for creating ambience for such dialogues with the potential tools at their disposal. Institutions imparting Museology training cannot, however, shirk off their responsibilities; an Inclusive Museology curriculum should be devised especially considering and taking care of the unique cultural complexities of the Indian society.

Such actions may give impetus to the preservation and rejuvenation of the threatened existence of the forms. It is possible to document the authentic forms; at the same time, controlled trials may be designed to evolve suitable application for the modern Indian museums. Besides the above, more importantly, it may help in

preparing the *Representative List of the Intangible Cultural Heritage of Humanity*, and the *List of Intangible Cultural Heritage in Need of Urgent Safeguarding*, in respect of India, as stipulated in the *Convention for the Safeguarding of the Intangible Heritage, 2003*.

The result of such efforts would help the museums to utilise the traditional forms for the betterment of the museums' programmes. On the other hand, the traditional forms may get new suitable patron, which are vital for their existence and preservation for posterity.

> Folk customs which have survived into the modern era are now maintained largely to assert a (mostly specious) local independence in an age in which local identity of any kind is threatened by mass culture, and most other links of memory and tradition with the past have been cut. Museums are perhaps the last non-partisan public institutions which can re-establish those links and that identity as such they have a role to play in maintaining public symbols of local identity, when they persist, helping to keep them alive, and documenting the changes in them as their meaning changes (Rattue 1996: 225).

At the end it must be mentioned that the Birla Industrial & Technological Museum (BITM), Kolkata often uses such media in its various extension programmes, such as inviting scroll-painters (patuas) during International Environment Day (Fig. 14.). Such examples are fit to be imitated.

Fig. 14. Patuas at work.

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The Amazing World of Nanotechnology

Susanta Sen

Abstract

Nanotechnology has become the buzzword of present day society. We find some news item flashing in the media every other day. Expectations and curiosity of the commoners have naturally been elevated to unexpected levels. This article gives an overview of the science and technology of the nano-world. Starting from a historical perspective, it is aimed to describe the development of this exciting ***new****(!) branch of science and technology as it stands today and what to expect in the future. Please note the exclamation mark (!) I have put beside the word new in the previous sentence. I shall leave to the judgment of the reader, whether the use of the adjective is appropriate in this context.*

The word *nano* is derived from the Greek word '*nanos*' meaning '*dwarf*'. Mathematically, the prefix nano is used to describe 1 part in a billion of something. Thus 1 nanometer is one billionth of a meter or 10^{-9} meter. A few examples will give an idea about what does such a dimension mean:

1. Consider a straight line 1 inch in length. If you break it up in small parts each one a nanometer (abbreviated as 'nm') in length, you will get over 25 million such parts.

2. Take a slice of the human hair across its diameter. If you put the 1 nm pieces of the above example side-by-side along the cross-section of the hair, you will need about 50 thousand such pieces to cover the entire width.

If you have already started feeling dizzy with those numbers, let me remind you that our world is made up of elements much smaller than a nanometer in dimension. Think of the Hydrogen atom, two of which we gobble up every time we drink a molecule of water. If you could isolate hydrogen atoms and put a number of them shoulder to shoulder along a line, it will take nearly ten (10) hydrogen atoms to fill up one nanometer of length; the tiniest distance you perhaps thought conceivable while working out the first example above. Imagine how many hydrogen molecules you swallow every time you drink a glass of water.

The numbers are no doubt overwhelming. But why are we so interested in them? The reason is, when known materials are reduced in size to such dimensions, their properties significantly change from those in bulk quantities, eg., gold changes colour to blue, red and orange as we decrease the size of the particles. Strength of materials has been found to increase many fold at such dimensions, which is utilized to synthesize new light-weight strong materials replacing metals for many applications. Corrosion resistant paints and coatings are also developed using nano particles as an integral component. As the particle size decreases their surface area to volume increases making them more reactive in many cases. This phenomenon led to the development of new generation of catalysts that can break down oil and grease molecules, such as those employed in self-cleaning coatings on glass and other surfaces. In the field of electronics, computers and communication, new generation electronic and photonic devices have emerged paving the way for high speed machines consuming lower power. High efficiency lighting and solar cells are expected to bring in a new revolution in power systems that may ultimately be a viable and safer alternative to fossil fuels than nuclear energy. In the field of medicine, new diagnostic tools and drug delivery mechanisms are being developed. In the First Nanotechnology Conclave organized by the Confederation of Indian Industries in February 2006, the then President of India, Dr. A.P.J. Abdul Kalam summarized the prospects of the field as "... *The next ten years, will see nanotechnology playing a dominant global business role, with the technology expected to go beyond estimates and cross the figure of one trillion ...*". The global business volume in nanotechnology is expected to reach anywhere between half to two trillion US Dollars by the year 2015.

So, what is nanotechnology? The nano-domain is loosely defined to encompass materials and systems having dimensions in the range of 1 to 100 nanometers. As we have discussed earlier, systems at these dimensions are composed of a few to a few tens of atoms or molecules. Considering this, we may say that **Nanotechnology** *deals with design, characterization and application of structures produced by manipulation of materials at atomic and molecular levels.* **Nanoscience** on the other hand is *the study of phenomena and characteristics of materials at atomic, molecular and macromolecular scales, the properties which differ significantly from those at a larger scale.*

Human inquisitiveness always generated fascination towards observing tiny objects. The journey began with the invention of an optical magnifying instrument in the late sixteenth century by two Dutch spectacle makers, Zaccharias Janssen and his son Hans, while experimenting with several lenses in a tube. The results of these experiments led to the invention of the telescope by Galileo in the seventeenth century and the microscope by Anton van Leeuwenhoek of Holland who used it to study bacteria and other living and non-living objects. The microscope was further improved upon in the following centuries and reached a level of perfection by the mid-nineteenth century. Recent developments in optical microscope design resulted in improving the contrast between the object under observation and its background through better illumination using polarized light, digital photography and image processing software. Looking into even smaller objects by increasing the magnifying power is not possible as the resolving power of the optical microscope, even with perfect lenses is limited to half the wavelength of the light. Considering an average wavelength of white light to be 555 nm, the resolution was limited to 275 nm. This means that two objects closer to each other by less than 275 nm would appear as one object. These dimensions are far too large when compared to molecular dimensions. We need shorter wavelengths to look at smaller objects.

The twentieth century started with Max Plank's revolutionary proposition of the quantum theory[1]. The exemplary experiments and ideas that followed in the following thirty years[2] changed the way scientists think about physics. The French physicist Louis de Broglie's hypothesis of matter waves, that a particle moving at high speed have wave like properties, proposed in 1925 and subsequently verified through experiments by others, led to the invention of the electron microscope in 1931 by the German scientists Max Knoll and Ernst Ruska. In this instrument, electrons are accelerated by an electric field strong enough so that their wavelength become orders of magnitude smaller than that of white light thus paving the way to look into molecular dimensions. The following years saw many new discoveries using this new scientific toy. Electron microscopes, however, remained as a diagnostic tool mostly for observing tiny objects in their various manifestations. These observations led us into exploring the nano-world as it is perceived today. A significant discovery of such observations is the mystery of the King Lycurgus Cup, a dichroic glass cup dating back to 4th Century AD Roman era. It looks like an opaque green cup in reflected light, but observed in transmitted light its appearance changes to a glowing translucent red[3]. Recent observation through a high power transmission electron microscope revealed that the glass contains tiny colloidal gold and silver particles which give rise to this unusual property. So, nanotechnology was practised even in the Roman era. But did they really know the science behind it? We will never know. In the Indian context, *Kajal* or *Surma* has been in use as a cosmetic of the eye since some unrecorded past, with the belief that it also has some therapeutic values. Modern studies show that the product contains ample amount of carbon nano-particles. In Ayurvedic medicine preparation we find references to processes known as *bhasma* and *churna*[4]. *Bhasma* is a process of generating fine powders by calcination of a substance in a closed pit, usually fired by burning cow-dung cakes while *churna* refers to mixing together of different powders in prescribed proportions.

People obviously knew methods of preparing nano-particles and put them into practical use for thousands of years. The applications, however, were limited to preparing the particles by some means and use them as an ensemble distributed evenly in a larger body. The idea of arranging arrays of particles of molecular dimensions in a pre-organized manner was first proposed by Richard Feynman in a historical lecture[5] entitled "There's Plenty of Room at the Bottom", in the annual meeting of the American Physical Society at the California Institute of Technology on December 29, 1959. He conceived the idea that the lens system of the electron microscope could also be used to focus the electron wave to a tiny region and impart enough energy so as to engrave any pattern on a surface, like we focus the Sun rays using a magnifying glass to burn a hole in a piece of paper. Many years later, this idea manifested in the Electron Beam Lithography system, that is now central to the manufacturing of modern VLSI chips. Feynman also mentioned in his lecture that like manipulating electron beams, a stream of ions can also be focused anywhere, albeit at a low enough energy, so that the molecules get deposited on the surface. This technique known today as Focussed Ion Beam Lithography is used in laboratories for the fabrication of nano-structures used in novel materials and devices. Extend your imagination a little further and think of "*arranging the atoms one by one the way we want them*" as Feynman proclaimed and synthesize new compounds that are yet to see the light of the earth. A fascinating new era will begin when scientists will be able to cook up compounds having the desired properties by combining the natural elements, like an expert chef prepares a recipe to a given taste from the ingredients in his kitchen.

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Tribology : A Potential Source of Energy Savings in Industry

Avijit Mukhopadhyay

Introduction

In this juncture of global industrialization the need of the hour is to stimulate the industrial growth at the same time to protect the global environment. Simultaneously the most important consideration in today's global industrialization is to save energy by judicious selection and control of the processes as well as to search and use of alternative sources of energy where possible.

The chief source of energy in our country is mainly thermal power and the lubricants produced mainly from petroleum products. All these are natural resources and it is needless to mention that the natural sources of energy are gradually diminishing at a rapid rate. In the recent time various researches are going on regarding different alternative energy sources, many of them are implemented effectively and going to be implemented. However, in industry specific cases and from practicality point of view alternative sources of energy have several constraints and thus the natural sources of energy are quite inevitable till date, particularly in large and medium sized industries. The very important question is thus, how to use the conventional energy sources very effectively? In this present paper light is shed on the potential sources of energy savings in industries from tribological point of view.

Tribology : A brief history

Tribology is a subject related to the science and engineering of interactive surfaces in relative motion. The phenomenon was known in the human race in the past several years, however the term tribology, superimposition of two Greek words 'tribos' (rubbing) and 'logos' (principle or logic), was coined only during 1966 by an UK committee headed by Professor Duncan Dowson. It is not out of place to mention here that one of the most significant landmarks in the history of tribological conquest in the United Kingdom was the publication of long research findings of Prof. (Dr.) Peter Jost in the year 1966. Not only in UK, that report paved the path of further tribological researches throughout the globe.

The sculptures on the tomb at Saqquara reveals the use of lubricants in a sledge. As shown in figure1, an Egyptian, bending down in posture, is pouring a liquid on the motion path of the sledge, that is, lubricating the sledge which is carrying a statue. This man is considered as the first 'tribologist'. In that curving it is observed that 172 men, most likely the slaves, are pulling a large statue weighing 600 KN. Later on Dowson (1998) estimated that total effort in that work was approximately 172 × 800 N, considering, each man was exerting a pull of about 800 N. Hence the coefficient of friction was approximately 0.23.

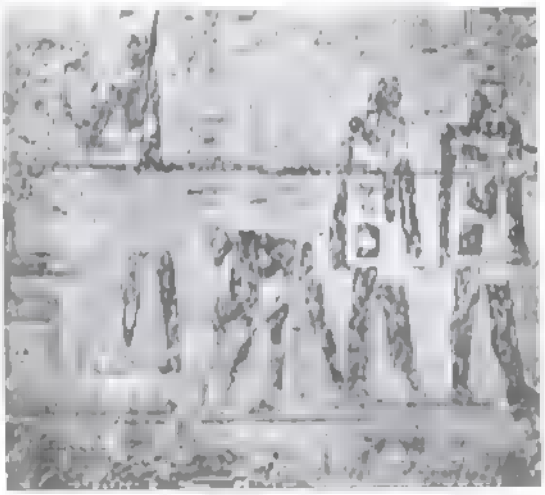

Fig. 1. Statue is carried on and the sledge is lubricated by an Egyptian.

Evidences are there which indicate the use of a mixture of olive oil and lime to lubricate chariot wheel during 1400 B.C. A figure of chariot is depicted in figure 2. War ships, recovered from Nemi Lake (c. 50 AD) near Rome, Italy, were also equipped with bronze rollers and balls to support the revolving platforms. Leonardo da Vinci (1452–1519), the famous painting personality, also studied about friction and sketched figures in that regard as depicted in figure 3. Marine chronometers designed by John Harrison (1693–1776) were based mainly on the tribological principle. A figure of the device is shown in figure 4.

Fig. 2. Picture of chariot during 1400 B.C.

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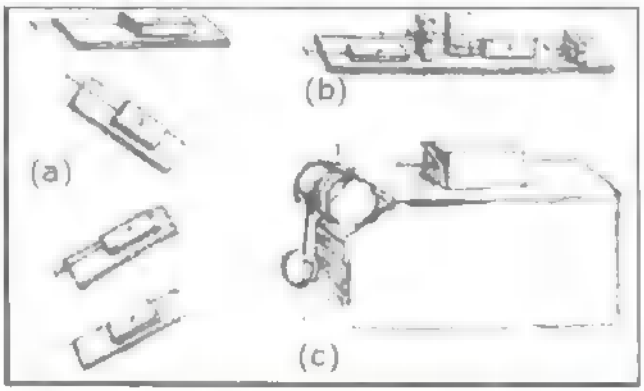

Fig. 3. Leonardo da Vinci's sketches regarding studies on friction.

Fig. 4. Marine Chronometer.

There are many more examples and all these prove the fact that the role and importance of tribology is not new. However, today's development in the area of tribology is quite complex to meet the requirement of machine specific applications. There are various developments, experiments so on and so forth. Still it is a complex phenomenon, not well understood and ill propagated too.

It is not out of place to mention why we should consider the role of tribology. On an average, 1/3rd of the total energy is lost due to friction and wear [STLE, US]. These loses ultimately cost the consumers at large. The loss is estimated at $200 billion in US alone. Not only the monetary losses but tribology related losses also impair the product life cycle as well as quality, reliability, safety, environment at large and many more.

Industry specific cases

Loss of energy due to friction as well as loss of materials due to wear ultimately lead to monetary loss. The tribology related loss, in general, occurs where two or more interacting surfaces are present under relative motion. However, in this section, some industry specific cases will be discussed in brief.

3.1 Automobile

In automobiles the potential sources of energy loss due to friction are

(i) the cylinders and piston rings – 25 to 50% of mechanical losses.
(ii) transmission – 75% of input energy is lost.
(iii) lubricants – not estimated.

In these calculations thermal efficiency of petrol engine and diesel engine is considered as 25-28% and 33 - 37% respectively. Saving of energy that is possible in the above three cases are estimated at 9 - 12%, 25 - 30% and 1.3 - 5% respectively. It is thus observed that maximum savings of energy is possible during transmission.

3.2 Power Plant

Loss prone areas in a power plant are

(i) various bearings – 4.2% of the out put.
(ii) turbine leakage – 2 – 4% of the out put.
(iii) pump seals – 4.5% of the out put.

Estimated potential savings in the above cases are 15 – 20%, 50% and 10% respectively. From the data it reveals that though the turbine leakage loss is not maximum but the saving potential is maximum in this area.

3.3 Manufacturing

Enormous loss due to machining is associated with different manufacturing operations like forging, casting, rolling, extrusion, metal cutting etc. and the magnitude of the losses are not estimated, at least there is no such authentic source of reference in this regard.

Irrespective of the type of industries and machining operations it is important to note that a proper machine criticality based assessment and ranking of the machines is the starting point for proper lubrication planning which ultimately will reduce friction as well as wear of the materials. Reduced friction will minimize the energy loss at large. The criticality assessment is a thorough scientific study based primarily on the following sequential steps:

(I) machine failure risk to employees, customers and environment at large

(ii) machine failure risk to production quality
(iii) rate of failure, mean time between failures, operating cycles etc
(iv) machine function in details
(v) hourly value of machine function
(vi) speed of failure
(vii) cost of machine repair
(viii) severity of the operating environment.

Operating environment severity includes but not limited to the factors like, atmospheric temperature, humidity, presence of dirt and dust, direct exposure of the machine to production chemicals, moisture or solid contaminants, machine stability and like others. Based on the criticality studies machines are ranked accordingly and then detail studies of the sources of tribological disturbances are initiated. All the lubricated components like bearings, couplings, gears, pumps, compressors etc. are studied in detail in this step. Having a complete break up of different components a proper lubrication plan is then carried out. It is not out of place to mention here that in the majority of the cases lubrication is not considered with its due weightage. It is not taken as a serious technical task. As a result sometimes proper lubrication is not met or sometimes parts are over lubricated which leads to the wastage of the lubricants which again is not justified in this era of energy crisis. Lubricants are toxic also in different cases. Thus over lubrication may also lead to some serious health hazard to the workers in the industry and the environment at large. Proper lubrication is thus a faculty which is to be nurtured with great care considering the roll of tribology.

Economic implication and savings potential

Improved tribological practice has the major savings potentials as indicated in table 1 below:

Table 1.

Maintenance and parts replacemen	45%
Losses due to machine breakdown	22%
Investment though increased availability & higher efficiency	4%
Increased overall plant life	20%

Truly speaking the thought process of tribology and the dire necessity of proper machine lubrication came into the picture during mid 1960's only when British Professor (Dr.) Peter Jost published his research findings for the first time about the influence of poorly executed lubrication practice in different industrial applications in Great Britain. His prediction about the potential savings that could be achieved by executing proper lubrication and maintenance tribology practice is summarized in table 2 below:

Table 2.

Maintenance and repair cost	20%
Lube procurement	20%
Reduced energy requirement (due to controlled friction)	7.5%
Reduced machine purchase cost	5%
Utilization of efficiency	1%
HR savings due to reduced repairs	0.13%

Estimated potential savings in US $ of more than 10 billion (103.61 hundred million USD) is given in table 3. This is based on the findings of the CAE (Chinese Academy of Engineering) investigation in 6 industrial areas during November 2006.

Table 3.

Metallurgical Industry	13.17
Energy (coal, electric power) and petrochemical industries	5.63
Railway Transport	7.77
Automotive Industry	69.85
Agricultural Machinery	1.77
Shipping Industry	5.42
SUM T O T A L	103.61

In the following table, country-wide losses and savings potentials due to tribological consequences are depicted:

Table 4.

Study Report by	National Loss/yr (in billion)	Savings Potential/yr (in billion)
UK 1966, Jost Report	£2	£0.51, 25% of total loss
FRG 1976,	DM 10	DM 5, 50% of total loss
USA 1979, ASME Report	$ 100	$ 16
USA 1985	$ 200	-
Germany 1983	DM 38.71	DM 0.62
India 1998	Rs. 400	Rs. 70

Conclusion

Friction and wear of materials due to ill tribological consequences will lead to the direct and immediate loss of energy. Considering the worldwide experience in the field of tribology it is estimated that savings up to 20% of the gross national products can be achieved by paying proper attention specially in the area of education, research and application. This effect is achieved without any significant investment.

Different survey highlighted the relative increase in the cost of conventional energy arising from the energy crisis worldwide and the total reserve of the natural resources are also diminishing gradually. This initiates the dire necessity of energy conservation and use of alternative sources of energy. Good tribological practice can save energy logically and the loss of material, failure of machine parts are also reduced due to reduced friction and wear which is achieved by judicious use of lubricants.

Thus, in this juncture of worldwide energy related thinking, the need of the hour is to nurture a good and logical tribolgy related practice in the industrial sectors too for the sake of energy savings and better utilization of resources.

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Sir M.Visvesvaraya – An engineer par excellence

K. Madangopal

The district of Kolar in Karnataka state is well known all over the world for its gold mines. Muddenahalli is a sleepy small village in Chikballapur *taluk* of Kolar district. Mr Srinivasa Sastri and Mrs Venkatalakshamma residents of Muddenahalli were blessed with a boy on 15th September 1861, who grew up to be a golden treasure to India. Mr Srinivasa Sastri was a scholar who devoted most of his time to the study of Hindu scriptures and performing pilgrimages. Mrs Venkatalakshamma was a pious lady of strong character. The child was second among their six children and was named Mokshagundam Visvesvaraya. The family name Mokshagundam is attributed to the name of a small village hamlet in Giddalur *taluk* of Kurnool district in Andhra Pradesh from where the ancestors of Sastris hailed before migration to Karnataka in the late 15th or early 16th century.

The learned family of Sastris was short of resources and poor in material goods. They could not afford to send their six young children to the nearby school in Chikballapur. Education began at home. Later, as Mrs Venkatalakshamma was more concerned about the education of her children, the family shifted to Chikballapur where the children went to the government school for primary education. The teachers in the school were impressed by the intelligence and discipline of young Visvesvaraya and encouraged him to read by lending him advanced books. After his primary education Visvesvaraya moved to Bangalore and stayed with his maternal uncle Mr Ramaiah for further education and subsequent career. He joined the Wesleyan Mission High School in Bangalore and completed Matriculation as topper in the then Mysore State. The result encouraged his mother to continue the studies of her son in spite of financial and domestic problems. Visvesvaraya joined Central College for Intermediate Education, but life was hard and uncomfortable. He decided to earn by doing tuitions to meet his educational expenses. He undertook private tuitions in a Coorgi family. His schedule was hectic and tiresome because his college, the place of tuition, and his residence were spread out in different corners of Bangalore. The only mode of transport in those days was travelling by foot. Hence he slept in the house of the Coorgi family, woke up early in the morning to give tuition to their children and went to his uncle's place for food and then to the college. What he lacked in *material comforts*, he made up through his courage and determination.

Visvesvaraya was a brilliant student in the college and was easily noticed by the British Principal of the college Mr Charles Waters. The principal took keen interest in his progress in the college and admired his keen sense of duty and punctuality. Impressed by his student Mr Waters presented him with a *Webster's Dictionary*. This dictionary was a constant companion of Visvesvaraya almost throughout his life and can be still seen in the museum at Muddenahalli. Visvesvaraya passed his B.A. examination in 1880 with distinction. The Principal of the college, knowing the financial situation of Visvesvaraya, recommended him for a job in the Directorate of Public Instruction. However, Visvesvaraya wanted to continue his studies to become an engineer. By then, the Diwan of Mysore Mr Rangacharlu was instrumental in instituting scholarships for students from Mysore to pursue higher education outside.

Visvesvaraya met the Diwan of Mysore and was successful in obtaining a scholarship for himself to study Engineering in the College of Science in Poona. Visvesvaraya joined the college of Science in Poona (now Pune) in 1881. His professors took keen interest in him and helped him complete his course in two-and-a-half years instead of the usual three years. He passed his engineering diploma LCE (equivalent to B.E.) in 1883 and topped in the college. His brilliant success in the examination brought him the James Berkeley prize and his appointment as Assistant Engineer in the Bombay Public Works Department, the post being guaranteed to the topper among the successful candidates.

Engineering career

Visvesvaraya started his engineering career in February 1884 at an early age of 23 years after his engineering degree in Civil Engineering. The opportunity to work with the Bombay Public Works Department provided ample scope to him to prove himself as an engineer. Within a short span of 20 months he was elevated as first grade engineer and his job was confirmed. He worked in different regions in the Bombay province and was responsible for construction of different projects including construction of bridges. Later he opted to move to Poona, and was given charge of civil engineering works like buildings and roads. While in Poona during 1894 he was deputed to design and execute the project of drinking water supply for Sukkur in Sind province (presently in Pakistan).

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Collector wells

The project had multiple challenges – the area was hot and arid, and they had to manage with minimum funding. An initial plan adopted by the municipality of Sukkur was to pump water from river Sindhu (Indus) to a hill nearby, filter it and supply the water to the town through pipes. However, they did not have enough money for the filters. After visiting the site and studying the ground situation compounded with fund crunch, Visvesvaraya came out ingeniously with an innovation of digging wells in the river bed itself close to the river bank to obtain spring water through percolation. Thus filtering was achieved without having to install filters. To increase the supply of water, a tunnel was driven from the bottom of the well under the flowing river. This was a technique rarely seen in those days, but is now standard textbook material under the heading "collector wells". The technique of digging collector wells on river beds is one of the most efficient ways of extracting filtered water. In regions where rivers are not perennial or have low flow conditions during most part of the year, the wells are placed in the riverbed to obtain uninterrupted supply of naturally filtered groundwater through highly permeable saturated riverbed aquifers. Collector wells can provide moderate to large quantities of filtered water naturally.

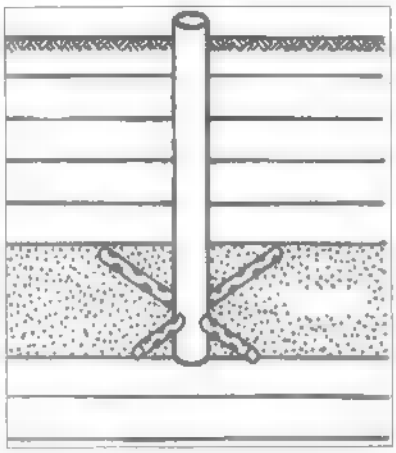

Fig. 1. Collector Well.

The design of collector well depends on parameters like river bed, surface water hydrology, study of geologic data like sand texture, density, size of grains, recharge potential of well, location of well and water demand.

Visvesvaraya was able to complete the work in a very short period. The then governor of Bombay, Lord Sandhurst inaugurated the drinking water facility built by Visvesvaraya in Sukkur in 1895, and in his inaugural addresses complimented Visvesvaraya as the most able engineer the project could have had.

After successfully executing several other assignments in other parts of the then Bombay state, Visvesvaraya was reposted in 1899 to Poona as executive engineer, Poona irrigation district. This was a turning point in his career. Now he had to manage politicians and farmers in addition to the management of irrigation works in Poona. The water from Fifa reservoir in Khadakavasla was drawn through Mootha canal for the drinking water supply of Poona city, Kirki military base, and farm lands surrounding Poona city. It was observed that water in the sharing canals was wasted in spite of water scarcity.

Rationing of water

Visvesvaraya's first challenge was to win public support for the system of rationing and regulating the supply of irrigation water. It was decided that water will be rationed for irrigation on a 10-day rotation period. The scheme was bitterly opposed by farmers backed by many prominent politicians like Lokmanya Balgangadhar Tilak and others. Balgangadhar Tilak wrote extensively in his newspaper *Kesari* opposing the water rationing action of the Irrigation Department. The scheme had to meet stiff opposition. However, the Government of Bombay expressed full confidence and backed Visvesvaraya. He then took an unusual step of inviting farmers and all those who were concerned for a public conference and debate organised at Fergusson College in Poona. The public conference was attended by interested parties. Visvesvaraya explained in detail the scheme of rationing the irrigation water. He even invited the farmers to take charge of the water management and offered them the Government support to meet incidental expenses. After hot debate the farmers were convinced that the system would be beneficial to them and agreed to adopt the system of water rationing. Thus the scheme of water rationing was introduced for the first time in the country, which was typical of Visvesvaraya's imagination and human approach, to the solution of problems in a democratic set up. The transparency, with which the scheme was implemented, was lauded by both farmers and politicians.

Block system of irrigation

Visvesvaraya devised innovative techniques that were well ahead of his time. One of his earliest contributions was the 'block system' of irrigation – designed to optimise, control and evenly distribute water supply to agricultural lands over a large number of villages.

In 1901, the Government of India appointed an Indian Irrigation Commission with Sir Colin C Scott-Monerieff as Chairman to recommend measures to be adopted to conserve water and promote irrigation in India. Visvesvaraya prepared a report on irrigation with new schemes to be adopted in the Bombay presidency and handed it over to the Commission. The new scheme of irrigation was known as block system of irrigation. The object of the scheme was to distribute the water resources effectively among a large tract of irrigation land. This was an effort to concentrate the irrigation in each village within a block of specified units in selected soil so that there would be a crop rotation in each block once in three years for maximum utilisation of water and to reduce water wastage.

Fig. 2. Block system of Irrigation

According to the scheme the agricultural land in a village was divided into three different blocks. The three blocks would grow three different types of crops. The first block would grow short-term water intensive crops. The second block would grow less water-intensive crops. And third block would grow long-term water intensive crops. Once in three years the land was regrouped and rotated into blocks so that the farmers would get opportunity to grow all the above three types of crops once in three years and they were assured of the required quantity of water. The sowing time for the crops was also suggested keeping in mind the rainfall period in the region, so that the available water could be managed to meet the long term water intensive crops during summer. The Indian irrigation commission under the chairmanship of Sir Colin C. Scott accepted his report and termed the scheme as "very complete and well considered" and recommended that it should be given a trial and later implemented in the entire country.

The scheme was well ahead of its time to be accepted by the farming community. The Government of Bombay entrusted Visvesvaraya with the responsibility of introducing the scheme. Visvesvaraya made intensive efforts to implement the scheme in the Bombay province under stiff resistance from the farming community. He organised interaction groups between the farmers and irrigation officials to explain to the farmers the advantage of the block system of irrigation. The scheme began on an experimental basis. Slowly the farmers realised the potential of the system. The scheme assured them of required water for long term intensive crops. The scheme was effectively brought into force in the Bombay province and the benefits of the system were shared between the farming communities without further complaints. In 1908 the Bombay legislative council was informed by its spokesperson about the complete success of the block system of irrigation in Bombay province and the success of the scheme was credited to Visvesvaraya.

Automatic sluice gates

Having established himself as an able engineer of high reputation and capability, he went on to innovate and build automatic sluice gates for Lake Fifa in Khadakavasla during1901-1903. Lake Fifa had a weir and it was difficult to meet the drinking water requirements of Poona city from the water stored in the weir during non rainy seasons. Here it is relevant to mention what Visvesvaraya wrote on the necessity of gates for the weir at Khadakavasla: "The reservoir overflowed every year up to a height of six to eight feet above the crest of the surplus weir. A system of automatic gates was designed by me to raise the storage water level of the lake permanently by about 8 feet (2 metres) above the original surplus weir. The gates held up water in the lake till it rose to the full height of the previous floods but whenever water rose above that level the gates automatically opened and allowed the surplus water to escape. When water in the lake again fell below the 8 feet level over the surplus water the gates automatically closed and stopped further loss of water." The gates increased the storage capacity of the reservoir by about 25% without raising the height of the dam. The gates were manufactured by a European firm. Visvesvaraya obtained a patent for his invention but refused to accept any royalty for his invention.

Fig. 3. Patent agreement for Sluice gates

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Sluice gates control or regulate flow through an opening or sluice in the body of the dam where the upstream water level is above the top of opening The automated floodgates allowed flood water to enter a reservoir without the water level exceeding the full reservoir level, thereby reducing the risk of submerging surrounding land. The gates are automatic because they open and close with the rise and fall of water in the reservoir. This was the first time that thought was given to using reservoirs for flood control, in addition to irrigation and power generation. The wheels are mounted on the end girders. The bottom of gate is so shaped that satisfactory performance and freedom from harmful vibrations are attained under all conditions of operation apart from minimising downward pull.

The automatic sluice gates designed and built by M. Visvesvaraya served for more than half a century satisfactorily. The same pattern of automatic sluice gates was later used in the Tigara Dam in Gwalior, at Krishnaraja Sagar dam in Mysore, and in other large storage dams. The design of automatic gates has been copied all over the world including adoption in Panama Canal. Other notable works during his stay at Poona was the preparation of piped sewage scheme in 1904 for the city of Poona (probably first such scheme for a city in India). He was also deputed to Aden to advise and report on the problems connected to water supply and sanitary in the city. His two reports on the city of Aden was duly considered and executed.

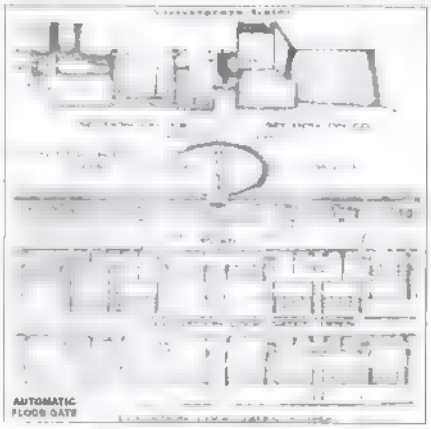

Fig. 4. Automatic Flood Gate drawing by Sir M.V.

Visvesvaraya by then had already superseded many of his seniors by virtue of his hard work and efficiency in the Bombay province. Discontentment among his fellow colleagues had started airing out. In 1908 the situation made Visvesvaraya to take a momentous decision of taking retirement from service. The Government of Bombay considered his resignation and although he was not eligible for pension, took a decision to grant him pension out of the way in view of his exceptionally meritorious service. Soon after his resignation he went on a foreign tour at his own expenses and visited many countries including Italy, Sweden, Holland, Denmark, England, Russia, Canada, and America and visited farms, factories, and irrigation works in those countries to widen his own knowledge about the new developments. His experience abroad benefited the future projects and economic developments which he took up subsequently in the country.

Services at Hyderabad

Soon after his return from abroad, Visvesvaraya was invited by the Nizam of Hyderabad to solve the problem of floods in Hyderabad caused by cyclonic rains and heavy water discharge from river Musi in to the city. Visvesvaraya took up this challenge in April 1909. He made a thorough survey of the catchment area and studied the flow of river. He submitted his recommendations to construct two dams across the river Musi and its tributary at a distance of about 12 km from Hyderabad. His proposal was duly considered and executed subsequently. During his tenure in Hyderabad he also planned the piped sewage disposal scheme for Hyderabad and Secunderabad cities. He was also involved in developing a system to protect Vishakhapatnam port from sea erosion. He left Hyderabad service in November 1909. But then he was once again associated with Hyderabad in 1922 and 1930 for planning a comprehensive scheme for the improvement of the twin cities including drainage schemes.

Visvesvaraya in the service of Mysore State

Visvesvaraya began his service as the chief engineer on 15 November 1909 in the state of Mysore. He initiated steps to build new railway lines and to take over the existing lines which were managed by the Madras & Southern Maratha Railway Company (British companies). He initiated action for various irrigation schemes including the distribution of water from Marikaniva reservoir. He became the chairman of Industrial Development Committee and Technical Education Committee. He was instrumental in establishing economic committees at district and *taluk* level in the Mysore province. He virtually initiated action for implementing development works in various spheres to ensure overall development of Mysore state. One of the major works was the design and construction of Krishnaraja Sagar dam, locally known as Kannambadi reservoir scheme, which began in 1911 and was completed in 1932.

Krishnaraja Sagar dam

The building of a huge reservoir across river Cauvery at Kannambadi to provide water for irrigation and electric power was inspired by his studies of the Aswan dam in Egypt and other experiences during his personal trip abroad. It did not take long to draw up the project to suit local conditions. The salient features of the dam are as follows. Type: masonry; maximum height above the lowest point of foundation: 43 metres; length at the top of the dam: 2,621 metres; gross storage capacity: 1,368,847 cum; type and number of gates: 161 lift gates.

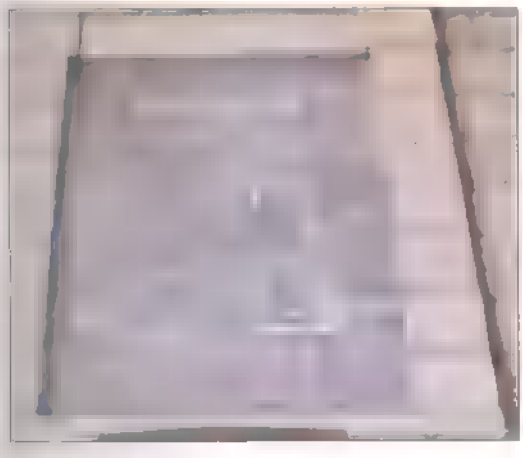

Fig. 5. Profile of KRS Dam

All reservoirs ought to have a device to pass excess inflows safely. Open spillways do this at the cost of a rise in water level. Visvesvaraya used his invention of automatic gates, which do this job without a rise in the water level. Such 48 automatic gates (out of 161 gates) in six sets of eight gates each were installed in the Krishnaraja Sagar (KRS) dam.

Fig. 6. Chain & Pulley arrangement for gate opening

Each set of eight gates are connected by means of chains and pulleys to a dead weight, which in turn is connected to a float working inside a masonry well, both situated on the rear side of the dam. The float and the counterweight balance each other and are located one in front of the other so as to have four gates on each side of it. When all the eight gates are closing the sluice vents, the counter weight is at the top of its run and the float at the bottom of the well. The well has an inlet pipe (1 ft diameter) from the reservoir to allow water into the well at full reservoir level. The well has also an outlet pipe. When the water level in the lake reaches the maximum permissible level, water rushes into the well and the float rises up.

The sluice vents then begin to discharge. When the reservoir level falls, the well gets emptied. The counter weight then comes up and the gates descend and discharge is stopped. (See the arrangement in the picture.)

Fig. 7. Skelton Gate of KRS Dam

Fig. 8. Well with float and counterweight arrangement

Each gate has the capacity to discharge at full reservoir level, about 1,000 cusecs (unit of measurement used to indicate the flow of one cubic foot per second of water). These gates are called "automatic gates" because they open and close at the rise and fall of water in the reservoir. The gates are made of cast iron and all the 48 gates were manufactured at the Mysore Iron & Steel works in Bhadravathi.

About sluice gates

A sluice is a water channel that is controlled at its head by a gate. Any gate that operates by allowing water to flow under it is termed as a sluice gate. There are many types of sluice gates, like the depletion sluice gates which are located at the lowest level in the body of the dam to empty the reservoir in the event of distress. It may be either wheel-mounted type or sliding type. The construction sluice gate is used for closing a construction sluice, which is normally plugged after construction. The crest gate which is mounted on a crest for the purpose of controlling the discharge flowing over the crest of the spillway of a dam. The fixed-wheel vertical lift gates comprise of, in general, a structural steel frame consisting of end vertical girders with properly spaced horizontal girders between them. The spacing depends on the design water pressure and on dimensions of the gate. The frame is held as a single piece by secure welding or riveting. Skin plate protects the structural framework from damage due to ice and heavy debris, minimises down pull, reduces corrosion and facilitates maintenance. However, in some cases as in the case of fixed wheel gates moving on track provided on the face of the dam, skin plate is provided on the downstream side. In exceptional cases, skin plate is provided on both downstream side and upstream sides, if the downstream water is above sill. In such cases the gates may be fully or partially buoyant. In case of fully buoyant gates, buoyancy is taken into account in determining the net balance of vertical forces and addition of ballast may be necessary to ensure lowering without difficulty. This problem is absent in the case of flooded gates but greater care against corrosion becomes necessary.

Diwan of Mysore

In November 1912, Visvesvaraya was invited by the Maharaja of Mysore to accept the office of Diwan. He was the first non-civil service member to occupy the post of Diwan in Mysore state. As Diwan of Mysore state, he was instrumental in galvanizing the state into progress. Soon after he assumed office he took into stock the prevailing situation with respect to general education and economic competence among the people. Only one in 16 was able to read and write; people were not fully employed. Visvesvaraya drew up a plan for improving the education and economic development of the region. He gave special emphasis to villages and mooted the idea of monitoring the progress in villages on a yearly basis. He urged people to take part in promoting progress of the region. He introduced constitutional reforms within the state with a large representative assembly to discuss budgets and a small legislative council with limited power of legislation. All the decisions were subject to the approval of the British.

Fig. 9. M.V. as Diwan of Mysore.

The Mysore economic conference started by him during his tenure as the chief engineer was further widened with three main committees for agriculture, industries, commerce, and education. The Committees collected statistical data at the micro level for evaluation and planning of development works. Education was given top priority. He passed a law for compulsory education of Harijans and girls. He was responsible for starting many educational institutions in the state. Some of the major educational institutions credited to him are the Agricultural College in Mysore, and Engineering College in Bangalore and Mysore, Sri Jayachamarajendra Polytechnic in Bangalore and the University of Mysore.

With the help of Industries Committee he was able to start various industries both in government and private sector. Notable industries among them are the Government Soap Factory in Bangalore, and the sandalwood oil factory in Bangalore and Mysore. A major industry which was set up due to his initiation was the Bhadravathi Iron and Steel Factory.

Finally he laid down the office of Diwan in December 1919 due to non Brahmin movement which rose to high level and was against the democratic views held by Visvesvaraya.

Post retirement

In his later part of life, Visvesvaraya was active by representing and advising in different committees all over the country for planning of economic policies and as an expert consultant for various irrigation works. He was the director of Tata Iron & Steel Company for 28 years from 1927 to 1955. In 1915, he was knighted by

King George V for his myriad contributions to the public good. The Government of India bestowed on him the highest civilian honour of Bharat Ratna in the year 1955 in recognition of his contribution towards the nation development. He was the founder president of the All India Manufacturers Organisation. He lived an active life throughout and was involved in advising many governments on various issues of irrigation and economic planning after independence. His works are spread out all over India and in present-day Pakistan.

Conclusion

Sir M. Visvesvaraya can be compared only with himself for all his achievements. His life remains an inspiration to people from all walks of life and stands tall as a legend in the history of India. He was an engineer, an economist, and a writer all in one of highest order. He showed a strict discipline and methodical attitude towards his work. He always planned his work with minute details. He had inexhaustible energy for work. His daily schedule noted in his diary remained the same throughout his entire life. His dedication and honesty towards work is unparallel. He lived a life of true human being and contributed to the development of the country.

Important milestones

* Designed water supply and sanitary system for Sukkur (Sind province).
* Established Deccan Club at Poona in association with Mahadeva Govinda Ranade and Gopala Krishna Gokhale.
* Designed a new system of automatic waste weir flood gate.
* Introduced the Block System of Irrigation.
* Usman Sagar and Himayat Sagar Reservoir project across the river Musi, Hyderabad.
* Prepared a scheme for flood protection work and underground drainage for Hyderabad City.
* Preparation of Project report for Kannambadi Anicut (KRS) across river Cauvery.
* Started the State Bank of Mysore.
* Started Mechanical Engineering School at Bangalore.
* Established Mysore University and the State Engineering College in Bangalore.
* Approved the plan to establish Bhadravathi Iron & Steel Works and several other industries.
* Established public libraries in Bangalore and Mysore.
* Automobile Industry Plan was prepared.
* Mahanadi flood control work in Orissa.
* Establishment of All India Manufacturers' Organisation as founder President.
* Established Sri Jayachamarajendra Polytechnic at Bangalore.
* Selected proper site for a new railway bridge on river Ganga in Bihar (Mokameh).
* Construction of Sharavathi Hydro-Electric Project.
* Establishment of Mysore Sandal Wood Oil Factory, Mysore Central Industrial Workshop, Chrome leather factory, etc.

Honours conferred on Sir M. Visvesvaraya

* Honorary Membership of London Institution of Civil Engineers
* C.I.E., (Companion of the Indian empire at Delhi Durbar)
* K.C.I.E., (Knight Commander of the Order of the Indian Empire)
* D.Sc., Calcutta University
* D.Litt., Banaras Hindu University
* Elected as an Honorary Life Member of the Institution of Engineers (India)
* D.Sc., Allahabad University
* D.Sc., Andhra University
* D.Litt., Andhra University
* Awarded the Honorary Fellowship of the Institute of Town Planners, India
* Bharat Ratna Award - Government of India

* D.Sc., Jadavpur University, Calcutta
* Durga Prasad Khaitan Memorial Gold Medal by the Royal Asiatic Society
* Fellowship of the Indian Institute of Science, Bangalore

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